Three Phase Induction Motor Control Using Simulink and FPGA SD 1019

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Introduction

- To control the Induction motor using the FPGA board.
- It is easier and cheaper to use this instead of DSP based board.
- FPGA are faster than DSP's.
- The whole control process can be solved using the control blocks from Simulink.
- Many features of the motor can be changed using the Simulink/Xilinx block sets.

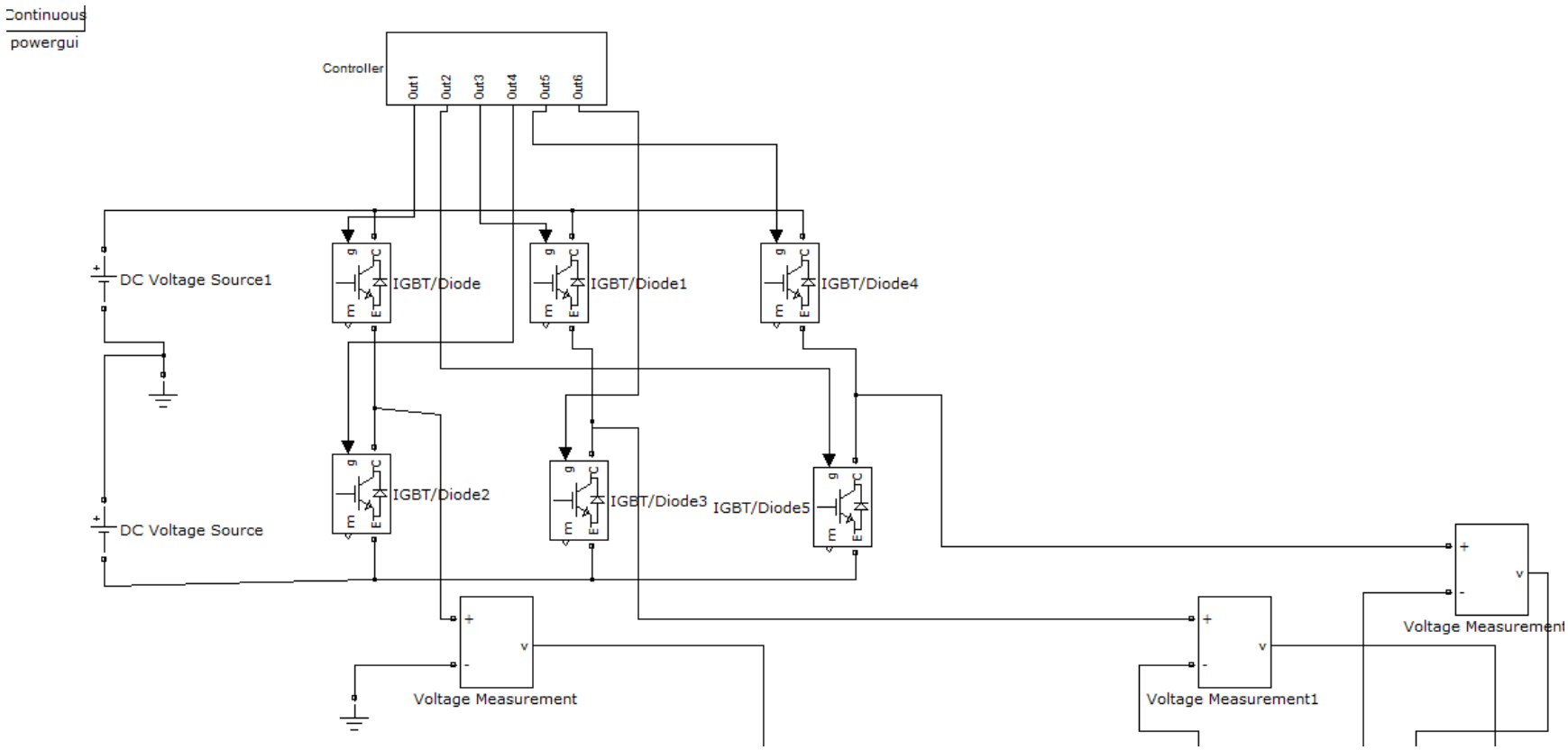
Requirements

- To get the simulation result from the Simulink.
- Learn to use the Altera Software.
- To control the speed of the motor.
- The three phase induction motor should run using the DC supply.

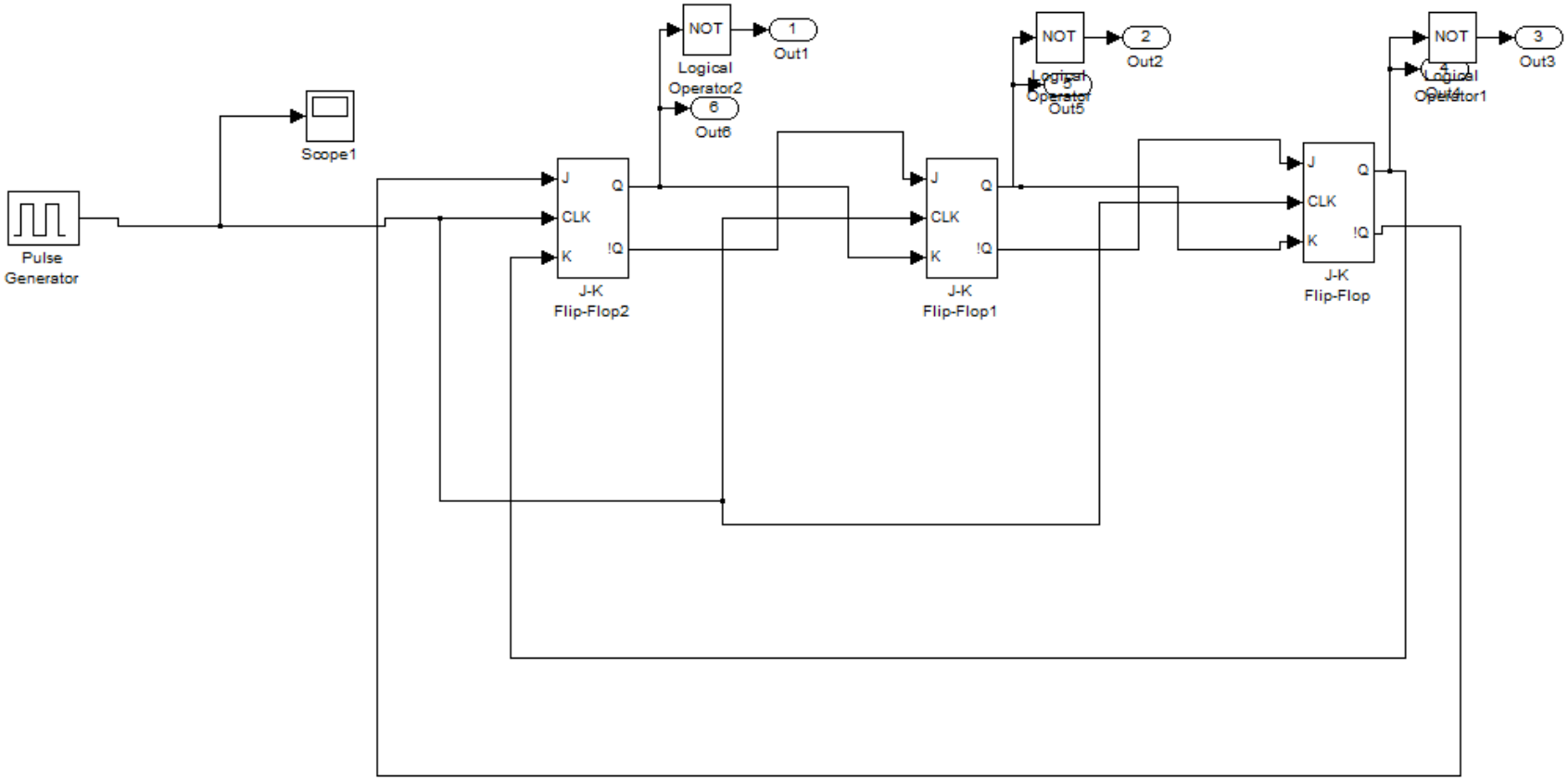
Option #1

- J-K Flip Flops
- This is one of the option we considered.
- Use pulse as an input
- Flip flop controls the rising and falling edges and supply gate impulses according to the clock .
- Basic idea was to run a motor using the logic function of flipflop.

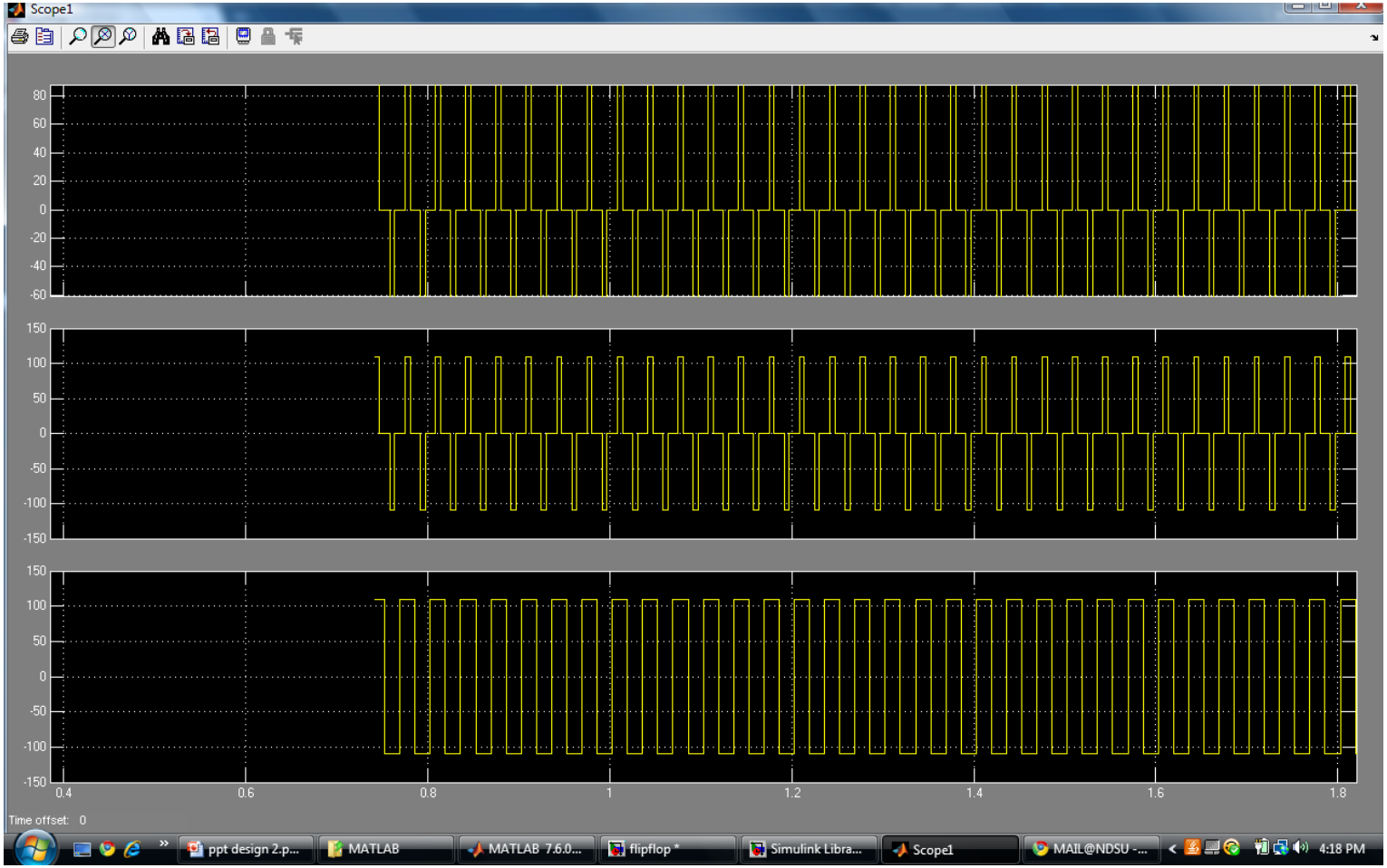
Using J k flip flop



Sub System for Simulation.



Output on Scope for pulse genrator using JK flip flop



Option #2*

- Space Vector Pulse Width Modulation
- Latest technology

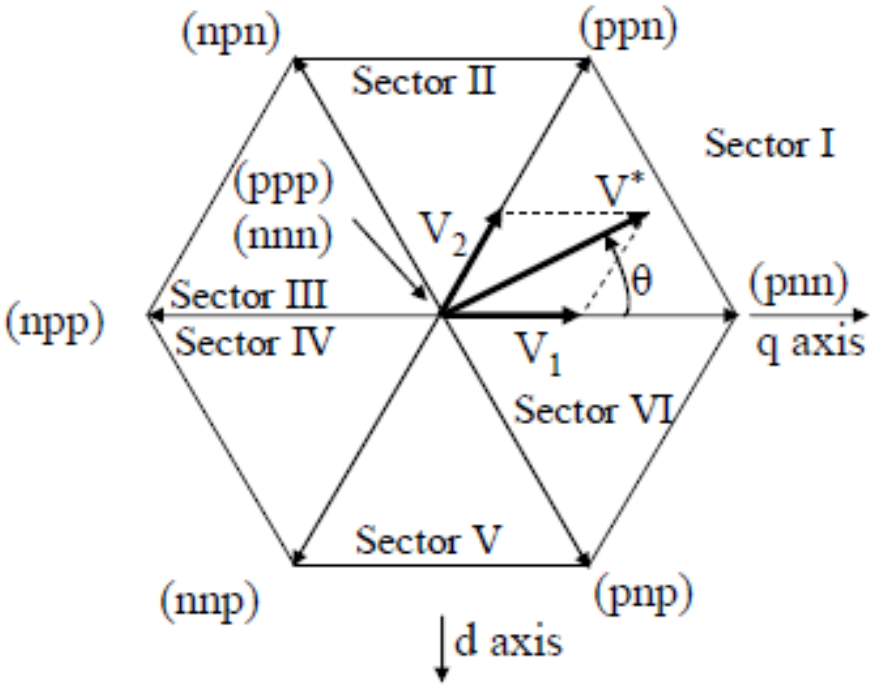


Fig. 2. Space Vector Modulation hexagon

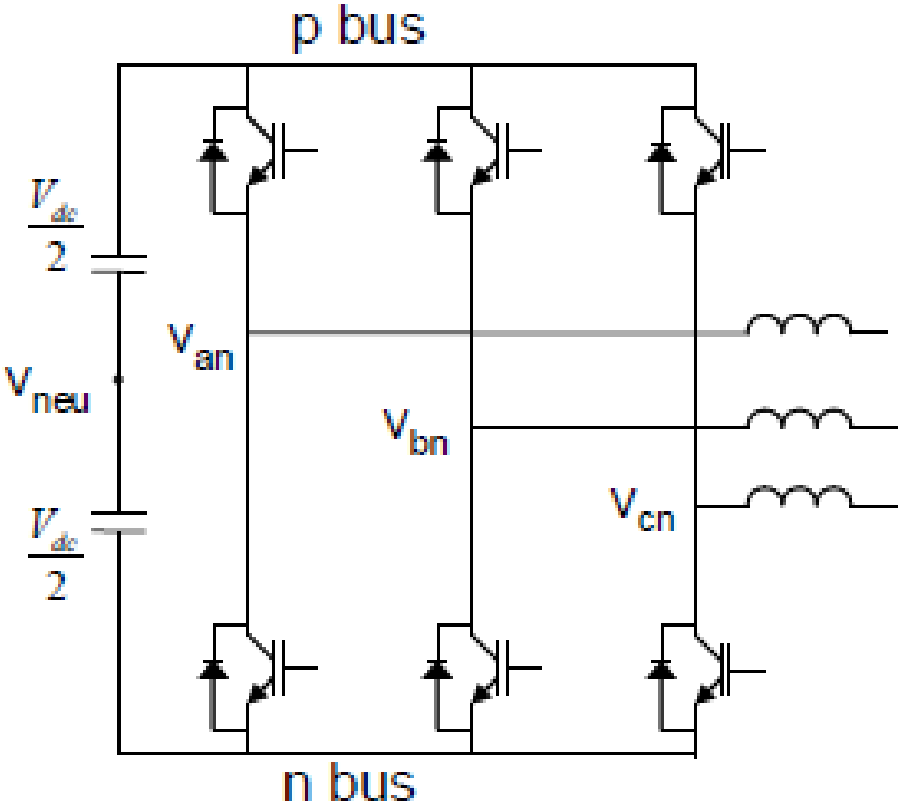
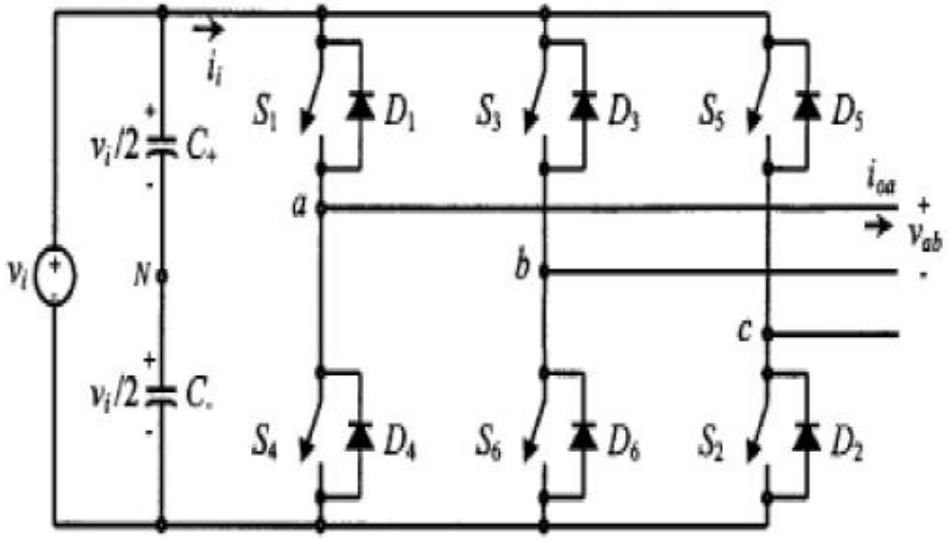


Fig. 1. Three phase voltage source inverter



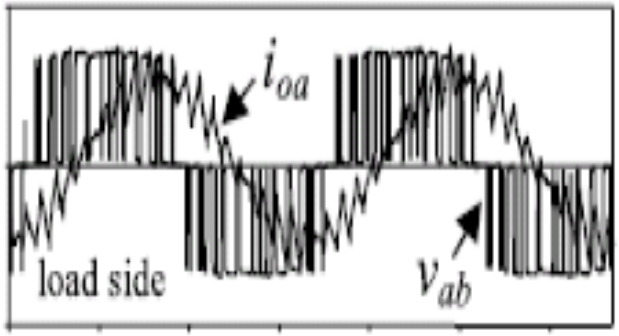


Fig. 4: Three-phase VSI topology.

State	State	v_{ab}	v_b	v_a	Space Vector
1, 2, and 6 are on and 4, 5, and 3 are off	1	v	0	$-v$	$V_1 = 1 + j0.5$
2, 3, and 1 are on and 5, 6, and 4 are off	2	0	v	$-v$	$V_2 = j1.155$
3, 4, and 2 are on and 6, 1, and 5 are off	3	$-v$	v	0	$V_3 = -1 + j0.5$
4, 5, and 3 are on and 1, 2, and 6 are off	4	$-v$	0	v	$V_4 = -1 - j0.5$
5, 6, and 4 are on and 2, 3, and 1 are off	5	0	$-v$	v	$V_5 = -j1.155$
6, 1, and 5 are on and 3, 4, and 2 are off	6	v	$-v$	0	$V_6 = 1 - j0.5$
1, 3, and 5 are on and 4, 6, and 2 are off	7	0	0	0	$V_7 = 0$
4, 6, and 2 are on and 1, 3, and 5 are off	8	0	0	0	$V_8 = 0$

Table 3: Valid switch states for a three-phase VSI

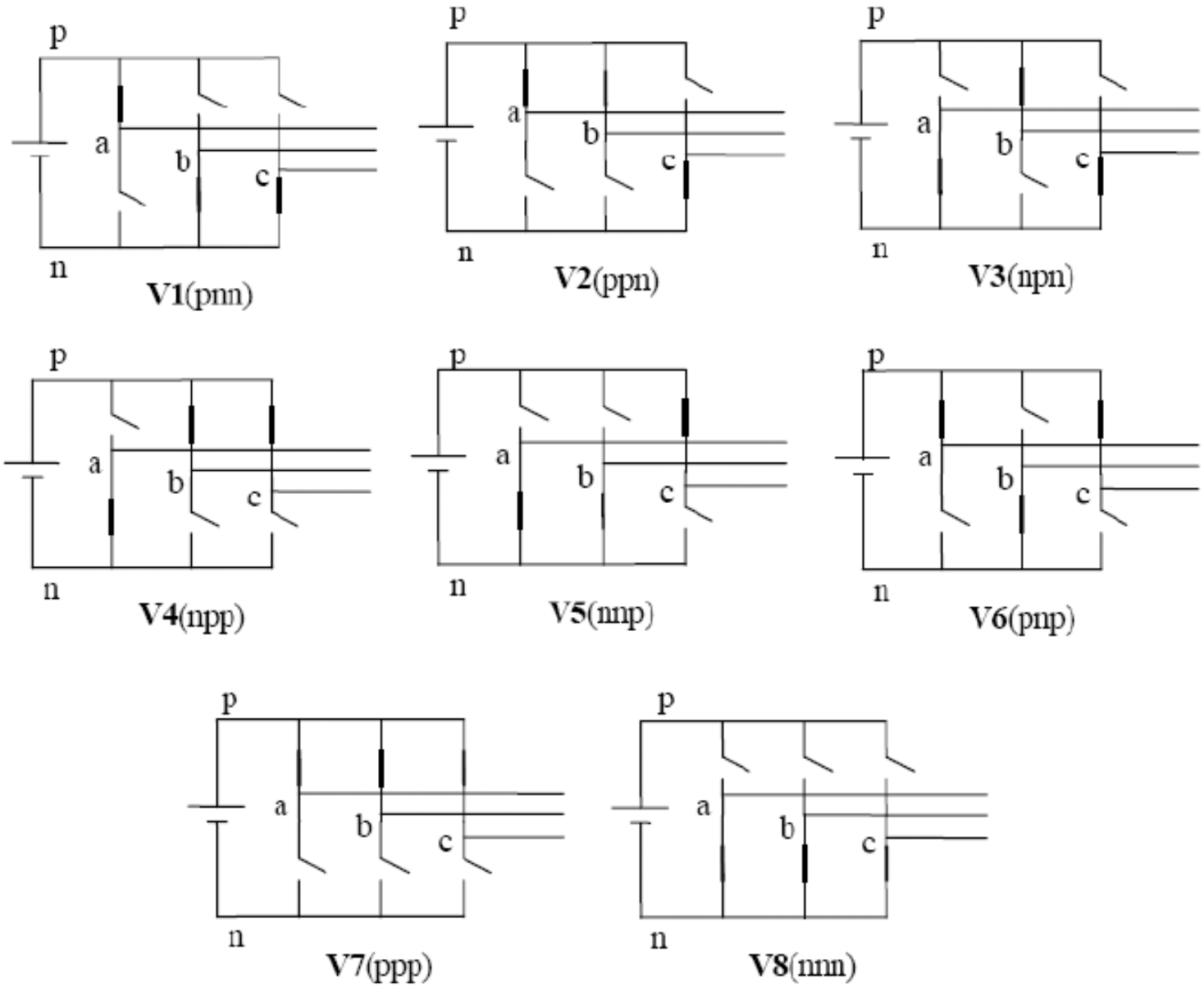


Fig. 10: Eight switching state topologies of a voltage source inverter.

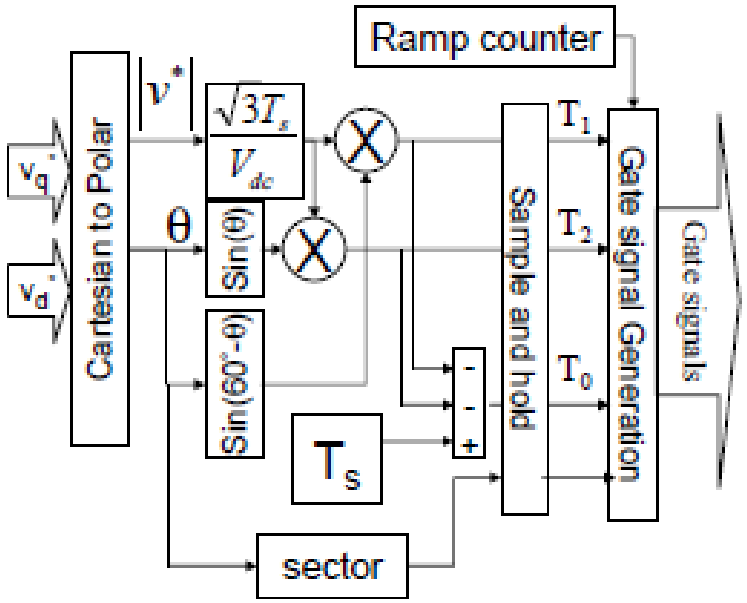
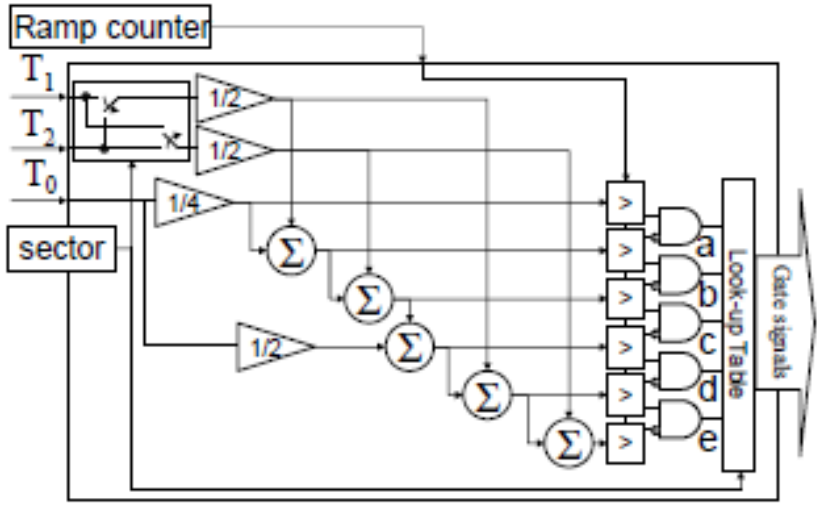
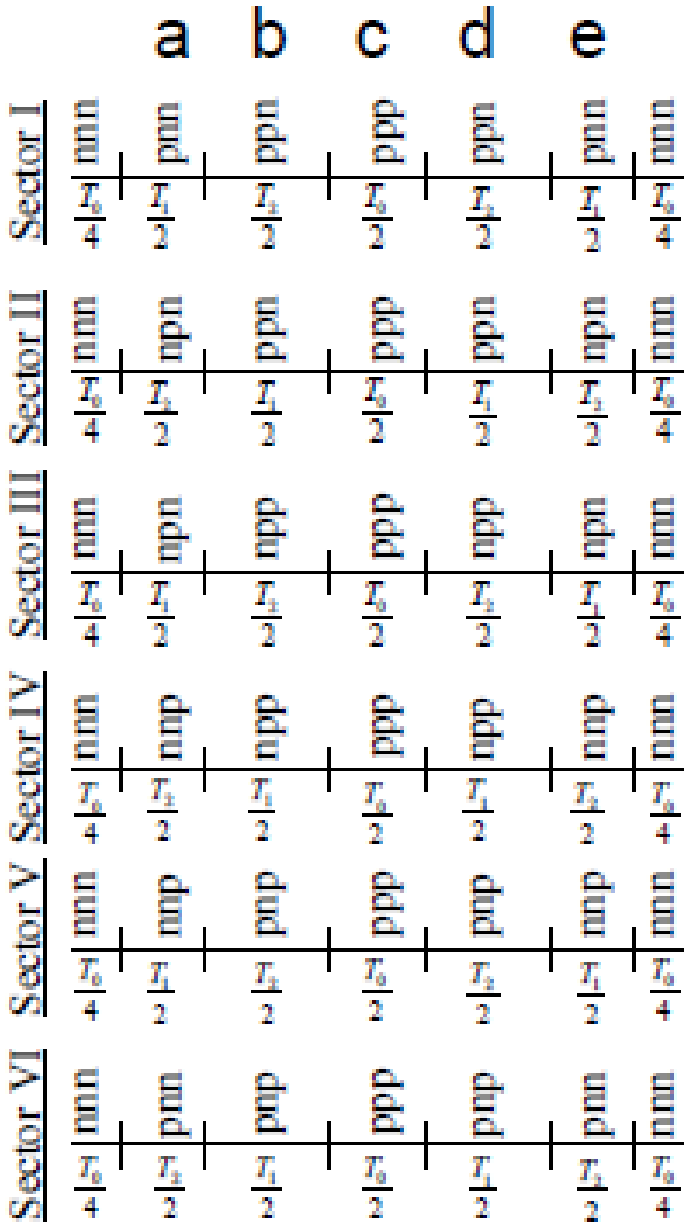


Fig. 5. Space vector modulation algorithm as implemented into FPGA





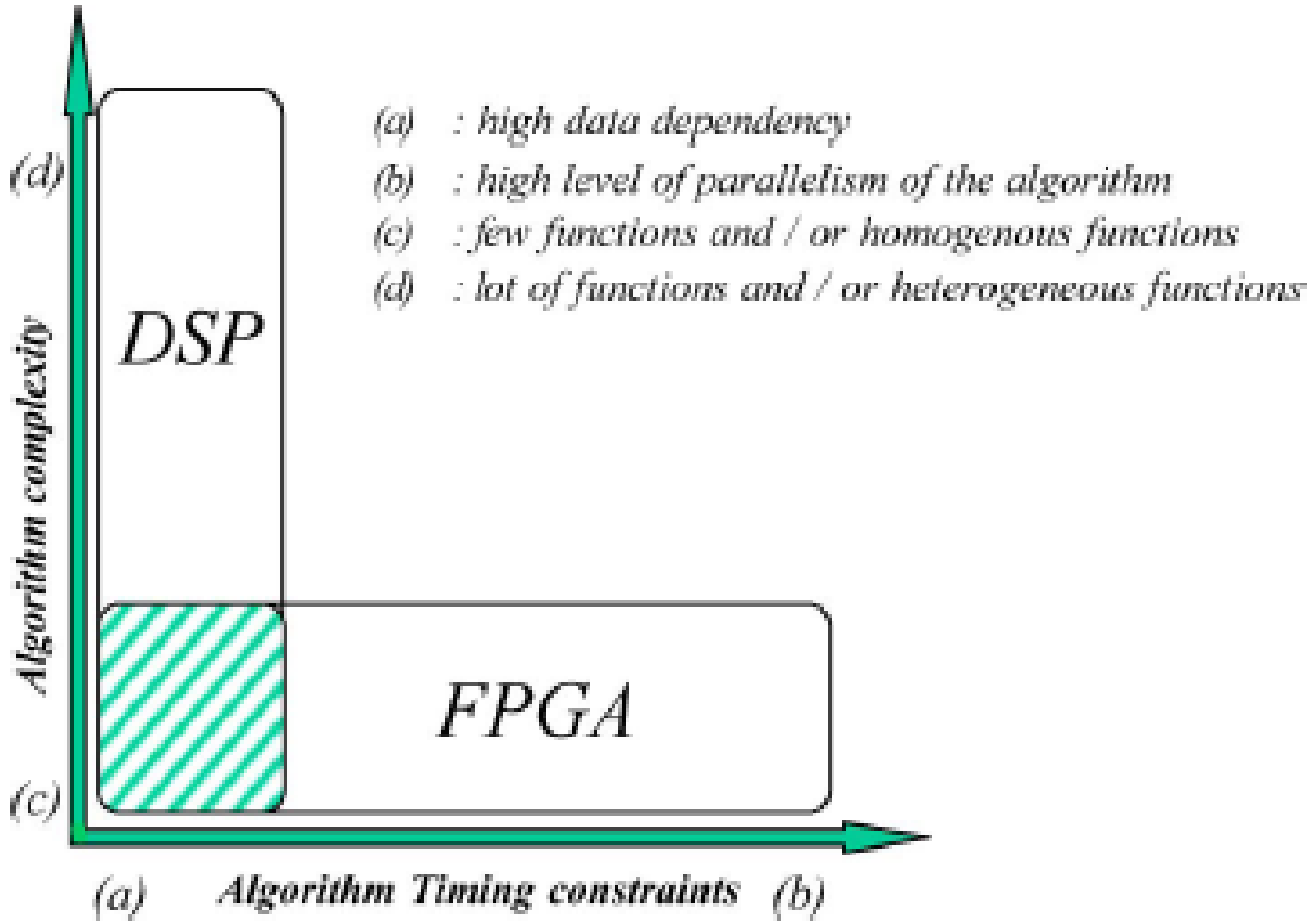
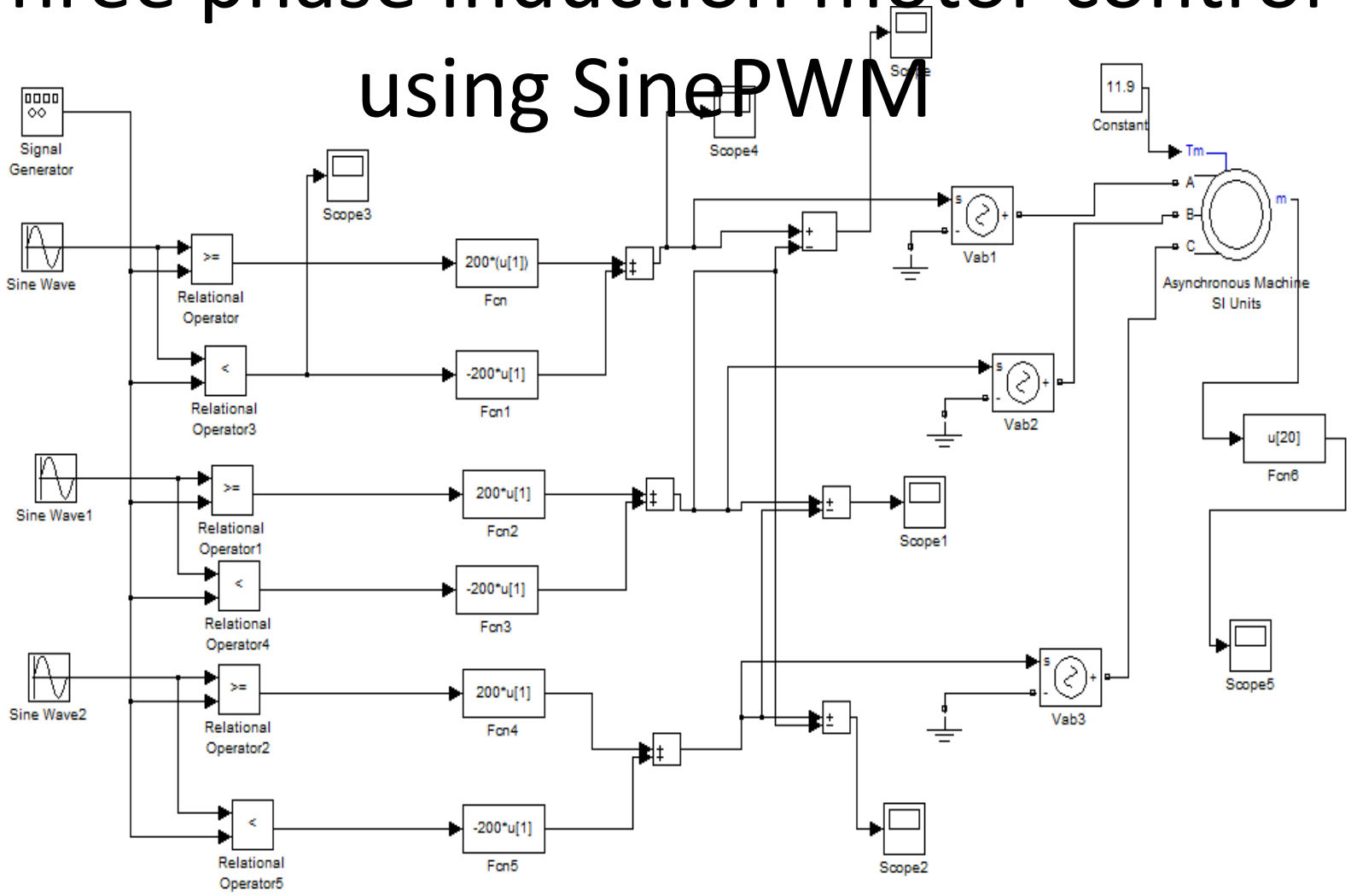


Fig. 8. DSP and FPGA domains of use.

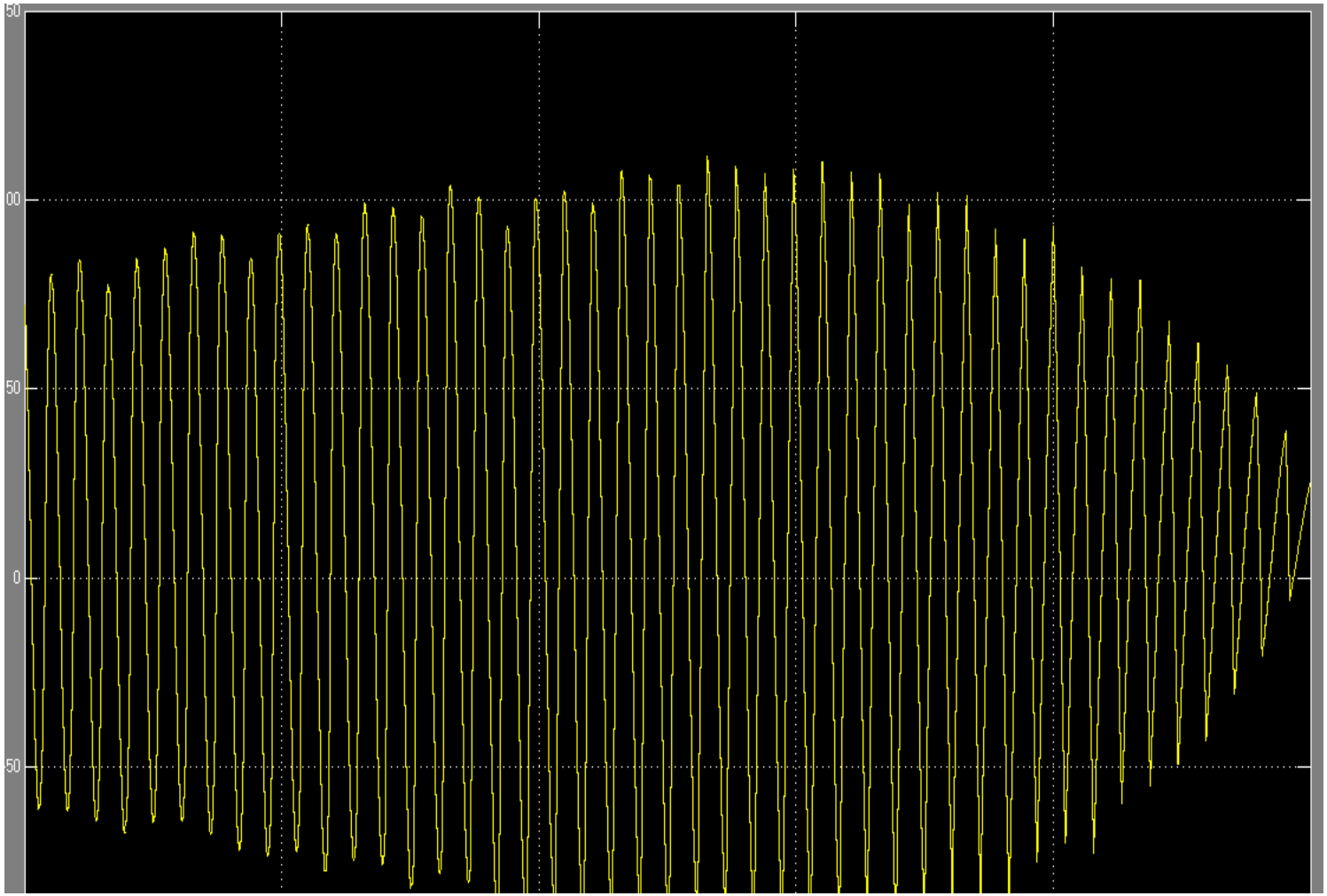
Option # 3

- Sine PWM
- The process of controlling the motor by changing the width of each pulse in proportional to the amplitude of the sine wave evaluated at the center of the same pulse.
- It is used in industrial applications.

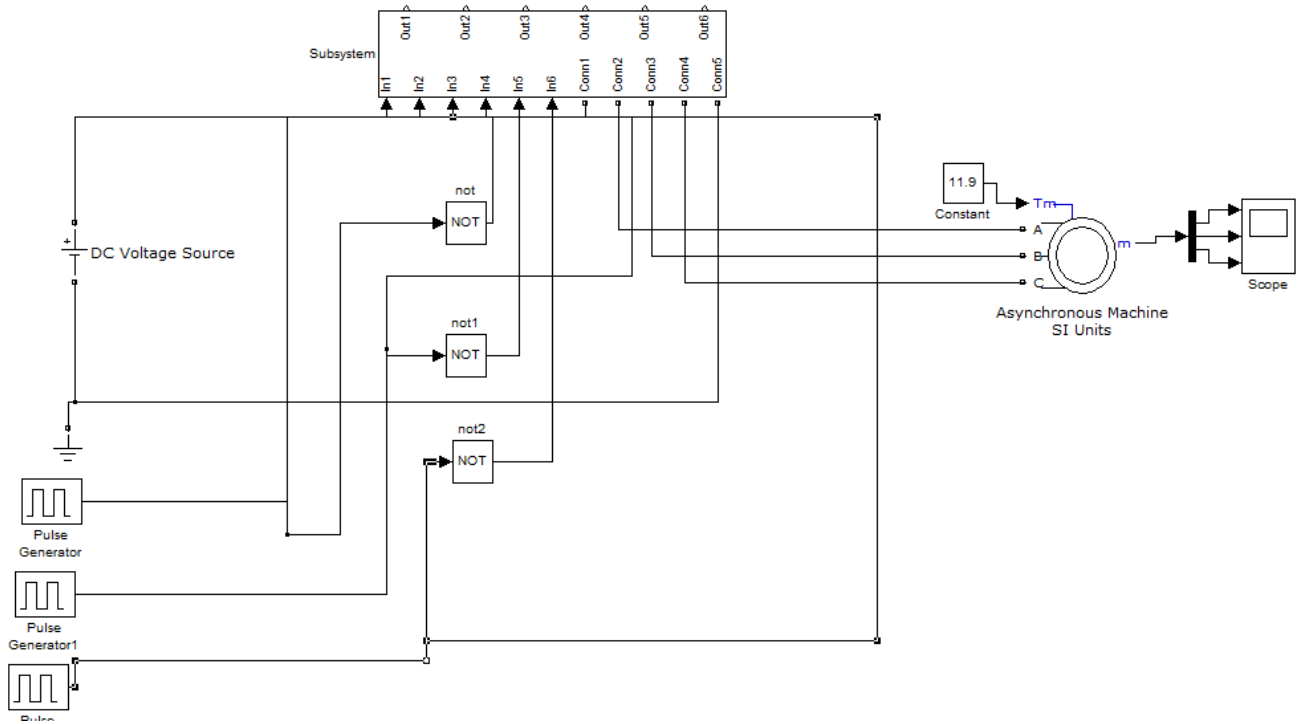
Three phase Induction motor control using SinePWM



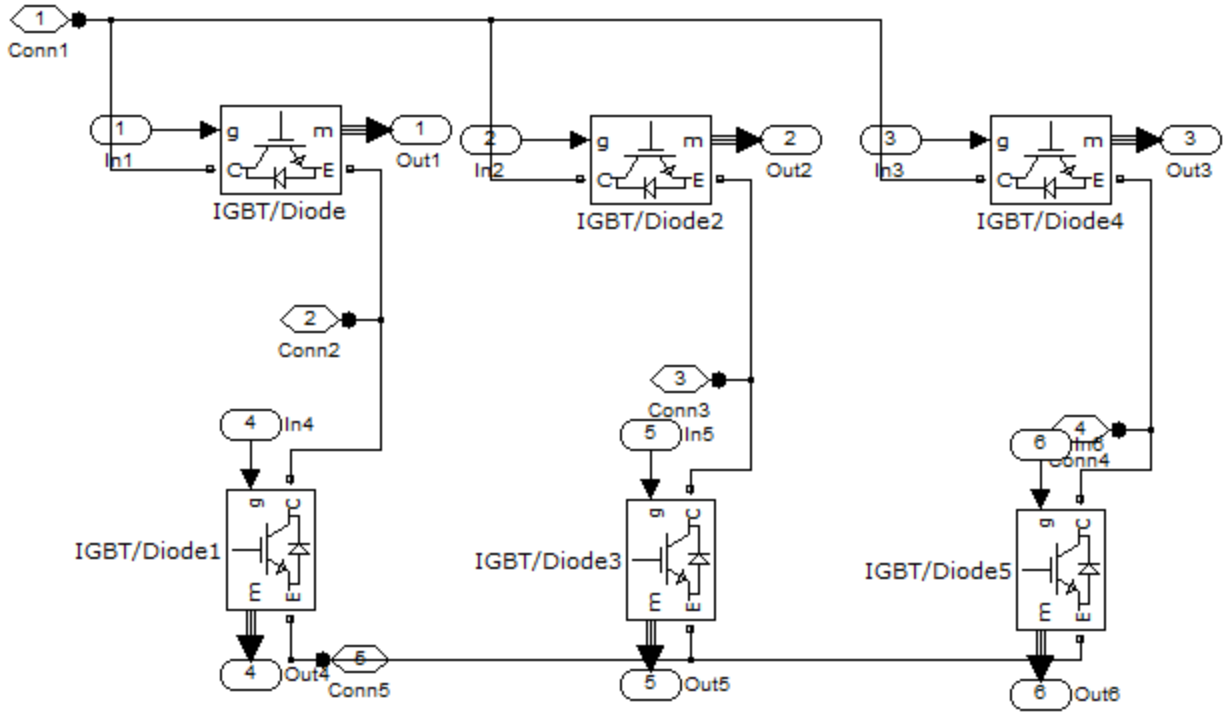
The SinePWM torque output of the motor



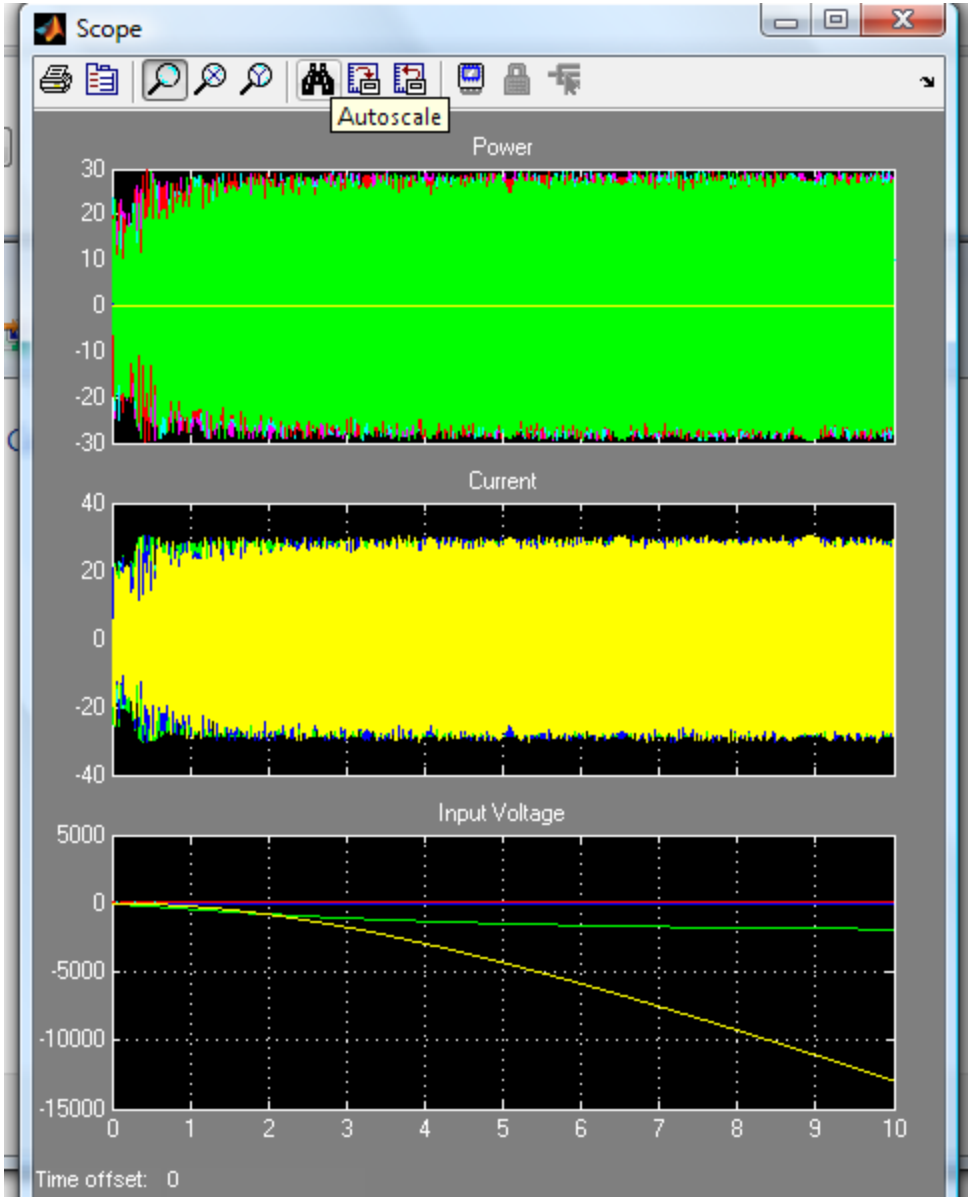
The Three Phase Induction Motor control using PWM



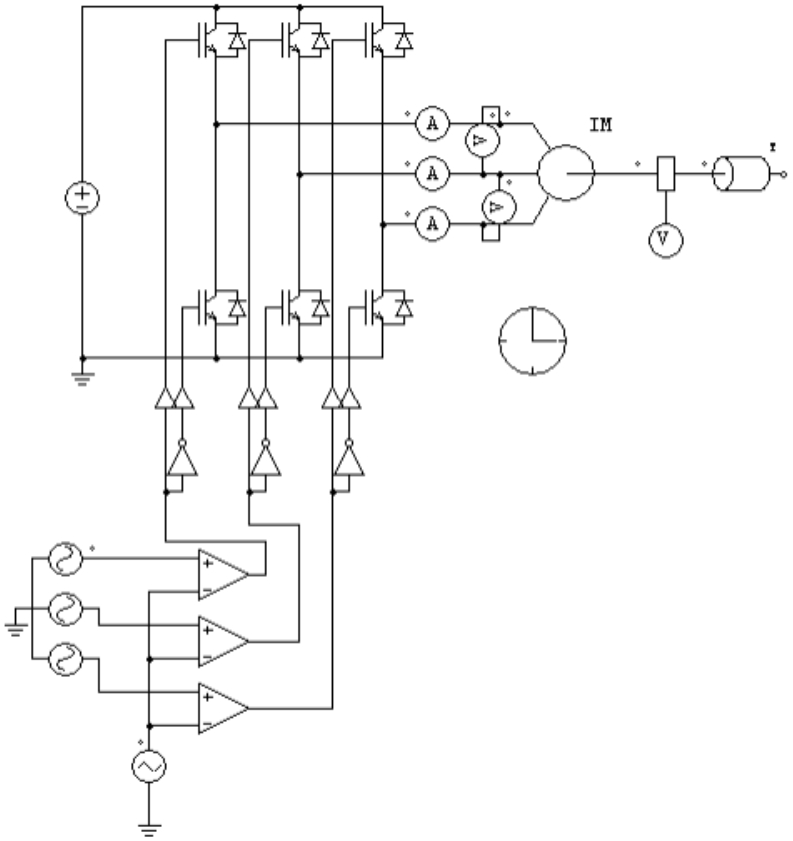
The three phase six inverter



Motor Parameter for PWM control



Three Phase Induction Motor Control in Psim



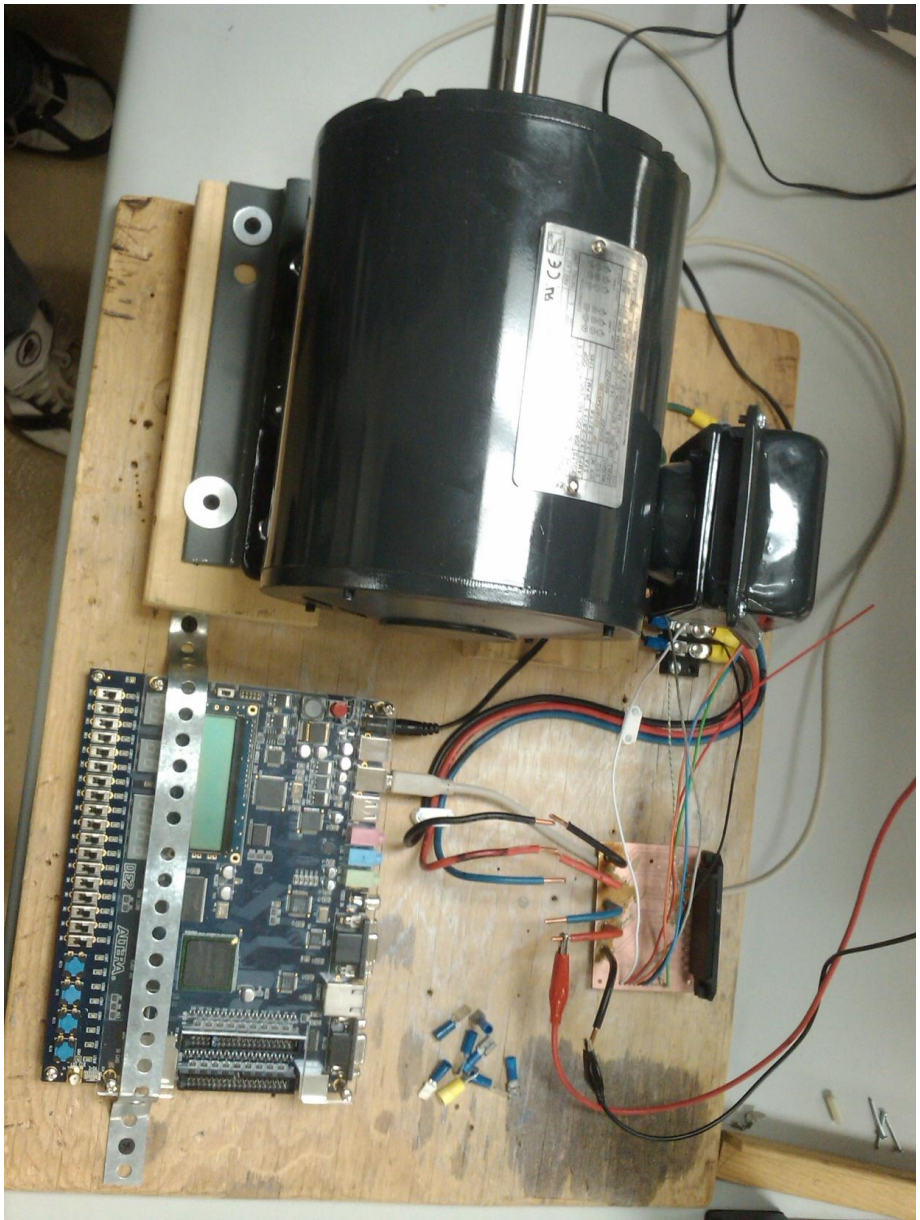
Project Status (research)

- Learned to use the Simulink.
- Built the Schematic for the control.

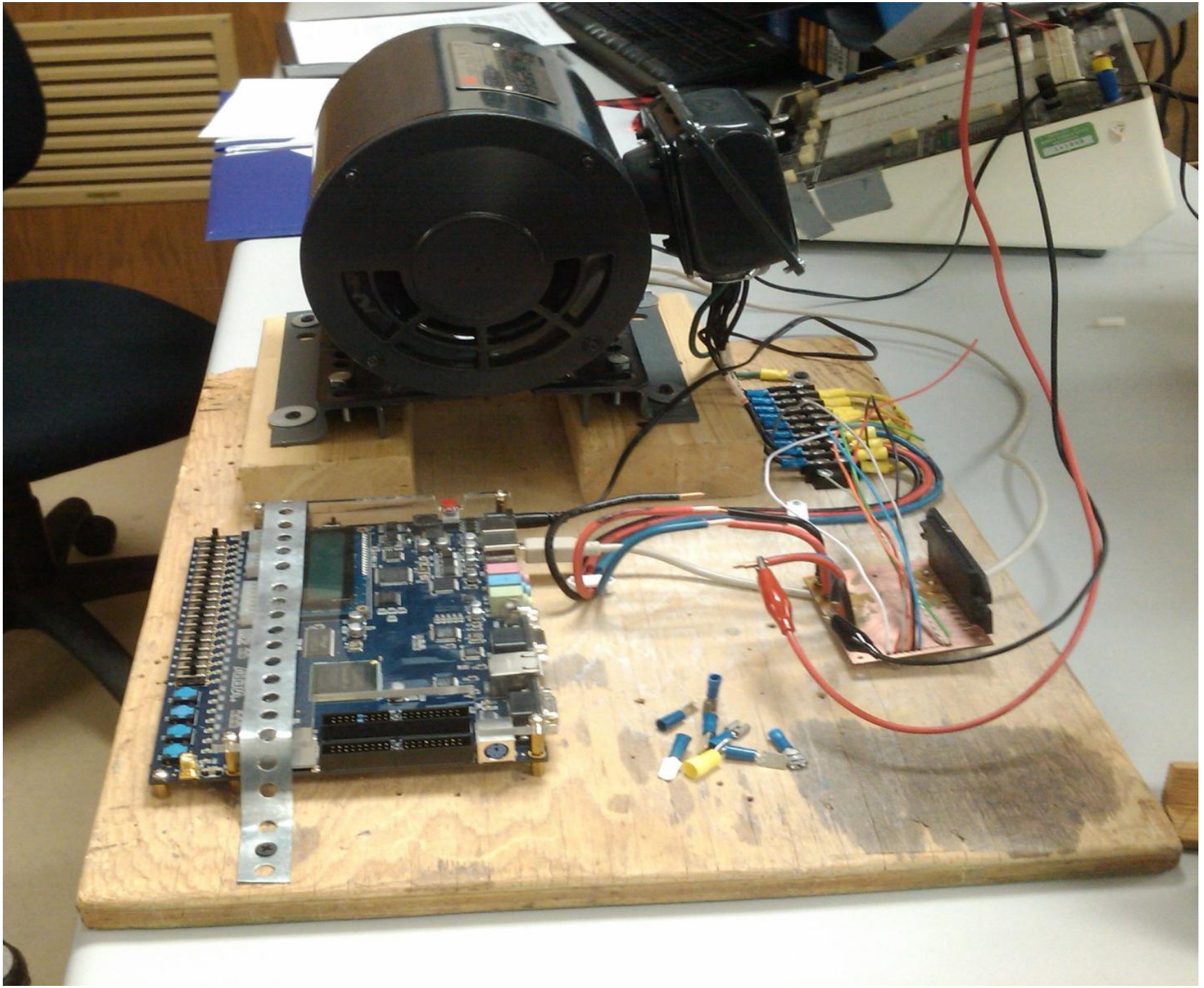
Programming

- Code we have
- Need to get the VHDL code for the FPGA.
- Programs we have and rest of project status during demo

Hardware



- Got all the necessary hardware for the project.
- Got all the necessary hardware for the project (except one part).



Task Remaining

- Get the VHDL code out of the Simulink.
- Use that VHDL code to download into the FPGA board and run the motor using the FPGA board.
- The software part of this project is almost complete but we still need to get the VHDL code to work in the FPGA and run the motor (Xilinx)
- Direct Torque Control next semester.

Timeline

Assignment	Date	Group Members	Status
Reading the paper about FPGA and Simulink	Sep 10th to Oct 1st	All three	Complete
Learning to use Simulink and its block	Oct 1st to Oct 15th	All three	Complete
Learn about the project and its components	Oct 15th to Nov 1st	All three	Complete
Assemble hardware	Nov 1st to Nov 15th	Thomas	Complete
Build the simulink block for three phase induction motor control	Nov 1st to Feb 15th	All three	Working
Inverters and Motor blockset in Simulink	Nov 15th to Dec 1st	Bibek	Complete
Space Vector Modulation in Simulink	Nov 1st to Jan 30th	Thomas	Working
Sine PWM control of motor in Simulink	Nov 25th to Dec 5th	Bibek	Complete
J-K flip flop design in Simulink	Nov 15th to Dec 5th	Sharan	Complete
Design the Simulink blockset using the Altera/Xilink software	Jan 1st to Jan 30th	Bibek/Thomas	Incomplete
Work on FPGA	Jan 30th to Feb 30th	Sharan	Incomplete
Work on the motor and Altera board	March 1st to March 30th	All	Incomplete
Run the motor changing the torque	April 1st to April 30th	All	Incomplete

Budget

Part	Quantity	Retail Cost	**Expected Cost**	Total Cost	Notes
FPGA Board	1	$400	$0	$0	We will use one that is already available from Dr. Ababei. For universities the discount cost is about $250.
Induction Motor	1	$200-$300	$200-$300	$200-$300	Dr. Yuvarajan will let us know which one to buy later.
IRAM136 Inverter	1	$50-$60	$50-$60	$50-$60	Dr. Yuvarajan's estimated amount.
Xilinx Software (Altera is free).	1	$0-$3000	$0	$0	Free three-month trial version is available. Plan to rotate computers.
Matlab/ Simulink Software	1	$6000	$0	$0	Installed on power lab computers. Student version is about $500.
			Total Max. Requested	**$400**	

Summary

- Completed all items in requirements capture. Just couldn’t get code to build.
- Need to get all the background information on how the Simulink works, the Altera software works and how to connect all this thing together was the challenge.
- Got through most of it. Now need to gather all the information got from the self study of the software and hardware and implement it.